Agnihotra: Brief Remarks from Combustion Sciences

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Introduction: *Agnihotra* is a daily ritual to be performed by every *Arya* twice a day. It is one of the five great duties (*pancamahayajna*) of every householder. Even in the student life, a *brahmacari* is expected to perform it in his/her *gurukula*. It has been an integral part of the Indian tradition that every marriage ceremony includes *agnihotra*. So much so that the young man and woman, as the bridegroom and the bride, conduct it as their very first act together soon after taking the vows to live together. It is also called *devayajna*, *havana* and *homa*. The last word *homa* is interesting that it sounds similar to the word home in the English language. Could it be that a house is worthy to be called home only if *homa* is conducted therein every day!

Vedic seers invented fire for the benefit of the mankind. While life without fire is unthinkable in the present times when almost all the technical gadgets perform with the help of the fire only – directly or indirectly – the sun is the primary source of energy for all the inhabitants on the earth, and the sun is nothing but a huge fireball in itself. The man-made transportation systems on land, air, sea, undersea and space function with the help of myriad of engines utilizing thermal energy of one fuel or another through a fire in its combustion chamber. The thermal power plants generate electricity through fire only. And, most importantly, we eat so many kinds of dishes after cooking them on fire. Thus, the ability to generate fire at our will must have been the foremost invention of the Vedic seers long ago in the faculty of the material sciences. Indeed, the very first word of the Rigveda, the very first book in the library of the humankind is *agni*, meaning fire, in addition to many other things.

But the most remarkable thing for the Vedic seers to invent is the ritual of *agnihotra*. It demonstrates their understanding of fire to the extent that they made it mandatory for everyone, twice a day. *Prima facie,* it sounds senseless to put the useful and valuable substances into fire. This is what will be discussed briefly, and at the end we would be left with an appreciation for the great ingenuity of the ancient Vedic seers.

Rsis (literally, seers – with the capability to see the truths that are invisible to a layperson) in ancient India understood the mechanism of fire, its ability to break up the substances into vapor phase, and the related buoyancy and other aerodynamic effects that it can be used as a mechanism to cleanse the air both indoor and outdoor. They knew the principle of Conservation of Mass, what is stated in the modern terminology as "No mass is created or destroyed." They knew that the oblations of different substances that are put into the fire may appear to vanish, but they don't vanish in the true sense. They merely become difficult to be seen by the naked eye because they have been transformed into vapor phase. It's as simple as evaporation of water that becomes invisible but it continues to exist in the form of the water vapor. Indeed this is what causes rainmaking clouds.

Vedic seers made the ritual of *agnihotra*, a multi-dimensionally useful affair. It becomes a spiritually enlightening experience because the selected verses from the Vedas and other allied Vedic literature are recited during the course of *agnihotra*. It became a family/community affair strengthening the bond of love among one another because it is performed in a group as opposed to, say, meditation that is a very personal affair – the former belongs to the family of Yaga whereas the latter belongs to Yoga. Of course, Agnihotra cleanses the air both within the room and outside too. Thus, it is the most ancient science to fight air pollution even in those days when humans were polluting air and water to a minimum extent, certainly several thousand times less than what we do today. *Agnihotra* can elevate us in all the domains of body, *prana* (vital forces governing vital functions in the systems such as nervous, cardiac, respiratory, digestion, etc.), mind, intellect, and the innermost spirit/soul, too. It encompasses all the meanings that are conveyed by the word *Yajna*. The word is derived from the root *yaj* that stands for *deva-puja-sangatikarana-danesu*. What is not well recognized is the Rsi's peculiar style that the term 'deva' has its shadow (called, anuvrtti) on all the three following terms and not merely on puja. That is, *Yajna* is a karma that: 1) honors *devas/deavtas*, both sentient and insentient, 2) that brings together devas in an assembly or otherwise, and 3) in the nature of sacrifice/charity for devas. Agnihotra is a valid Yajna on account of: 1) bringing together noble people with respect, 2) ghee and other herbal substances are employed together to perform it, and 3) the overall spirit behind the endeavor is to benefit others by way of purifying the air.

There are other alternative ways to look at this exercise. *Agnihotra* can truly be characterized as a *Yajna* because first, it is for cleansing of air, a *devata* of insentient nature. Furthermore, it enhances the characteristics of the herbal substances (that are also *devatas* in nature) multifold, as we will see later. Two, it is a group activity when a number of people assemble together with a positive frame of mind and intellect. Three, it amounts to making a sacrifice from a personal point of view though the benefits of the same would be obtained by all beings in general. The oblations of many valuable substances are offered into the fire, which amounts to sacrifice. The Verses are chanted with the endings of "*idam na mama*", i.e. this is not mine. This reinforces in mind that all the material possessions of ours in the world are actually not quite proprietary in nature; it is merely for the purposes of transfer and diffusion to others in keeping into the spirit that all the wealth is actually that of the creator – She is truly the Creator and Owner. What follows is a brief description of *agnihotra* from the combustion sciences point of view. It is assumed that the readers are familiar with the ritual of *agnihotra* as such.

Essentials of Combustion: Combustion is said to occur if a fuel is oxidized (generally by the atmospheric oxygen) giving rise to thermal energy. Typically, mere presence of the fuel and oxygen does not lead to combustion. For example, there is fuel and oxygen present in the automotive fuel tank but no combustion takes place therein. It must be initiated by a source of ignition – what a spark plug does in a gasoline engine or a lighted matchstick may do in the fuel tank.

Once the combustion takes place, thermal heat is produced that was inherent in the particular fuel. This gives rise to increase in temperature. Some fuels release much more

energy than some other fuels. For example, typical hydrocarbons fuels such as methane, propane, gasoline, diesel, etc. have their thermal energy in the range of 10,000 calories per gram of fuel, called Calorific Value of the fuel. Upon combustion (that is, oxidation by atmospheric oxygen) the final temperatures may be as high as 2500 degree Celsius. There are fuels that have smaller calorific values such as cellulose materials, wood being one of them. Typical firewood may have calorific value around 3000 calories per gram of fuel – about one-third of the hydrocarbon fuel. This is easy to understand because hydrocarbon fuels have only carbon and hydrogen atoms in their molecular structure while cellulose materials have oxygen atoms too in addition to the carbon and hydrogen atoms. That means that the molecular structure of cellulose materials has embedded oxygen atoms. In other words, they are partly oxidized within their molecular structure and upon combustion they can be further oxidized by the atmospheric oxygen to the remaining lesser extent only. Hence their calorific value is much lower. Upon combustion, they are likely to cause maximum temperatures in the range of 800 – 1200 degree Celsius only.

Upon complete combustion, we expect formation of carbon dioxide and water vapor as the products. Due to the deficiency in the availability of oxygen, or other possible reasons some fuel remains unburned, or gets only partially oxidized to carbon monoxide. Unburned fuel and carbon monoxide are considered undesirable pollutants for the atmosphere. Also, if the combustion gives rise to high temperatures in the range of 2000 degree Celsius or above then the atmospheric nitrogen and oxygen may react with each other, forming the oxides of nitrogen – another family of undesirable pollutants. Thus, we can see that while combustion of a fuel gives rise to thermal energy, it produces some undesirable pollutants such as unburned fuel, carbon monoxide and the oxides of nitrogen. Nowadays, when humans use energy in greatly unchecked manner even carbon dioxide is considered as undesirable because of it being one of the so-called greenhouse gases.

Combustion in *Agnihotra*: *Agnihotra* consists of a base fire generated in a specially designed vessel built/fixed on the surface of the level ground. Burning firewood of certain specified characteristics forms the base fire. Firewood being a cellulose material has much lower calorific value. The base fire has much lower temperatures than in the typical engines. To this base fire, certain substances are added periodically in the form of oblations. Purified butter (*ghrtam*) and several herbal substances are added into the base fire. Maharsi Dayananda Sarasvati (1825-'83) has stated in *Satyartha-Prakasa* that the herbal substances to be added into *agnihotra* should be 1) wholesome, i.e. health givers, 2) anti-bacterial, 3) aroma-builders, i.e. deodorants, and 4) sweeteners.

It should be emphasized that the purpose of *agnihotra* is not to burn the substances that are added in the form of oblations; rather, it is to vaporize them, i.e. to heat them just to the extent that they are transformed into vapor phase – the process is called sublimation (from solid to gas phase for the herbal substances) or vaporization (from liquid to gas phase for ghee) as opposed to combustion. Combustion changes the chemical structure of the reactants that they transform into new products such as methane will burn in air to form carbon dioxide and water. However, sublimation and vaporization merely changes

the substance into its vapor phase without altering the molecular structure; it is a physical change only. Sublimation and vaporization are endothermic process that they require heat that is supplied by the base fire. Thereby the vapors diffuse into the surrounding air and transform the air quality. Coupled with the buoyancy (causing the heated air to move upward) and aerodynamic effects due to the thermal energy released by the base fire, the vaporized substances traverse to all nooks and corners of the enclosed room. In other words, the base fire is utilized to convert the herbal substances into gaseous phase, and furthermore, to aerodynamically transport the same to the entire surroundings in a most effective manner. The buoyancy forces enhance the transport processes.

It must happen that a fraction of the substances added as oblations do go through combustion process, especially so must be true with *ghrtam*. Their effects upon combustion is not expected to be harmful to the atmosphere because they are carefully chosen to bear one or more of the above four characteristics. Details of the related chemistry have been sufficiently dealt with by Satya Prakash in "Chemistry of Agnihotra" published by Jan Gyan Prakashan, New Delhi, and by Ram Prakash in "Yajna Vijnana Vimarsh" published by Aneeta Arsha Prakashan, Panipat, India – both the authors were chemists. Indeed, in their opinion, formaldehyde is the major component produced by their combustion that has several desirable properties such as anti-bacterial, and anti-fungal.

Overall result of the *agnihotra* is that the desirable substances in their vapor phase can be inhaled through the nostrils by one and all. This mechanism of intake as opposed to the direct means through the mouth (in the liquid and solid phase) is more efficient by a factor of several hundreds. Also, it seems to be the only way to cleanse the indoor air. As opposed to a typical air freshener, which simply attempts to neutralize the stale air, agnihotra drives the indoor air out thereby causing outdoor fresh air to move in. In addition to this, it effectively neutralizes the stale indoor air as explained by the characteristics of the herbal substances utilized.

Let us now discuss the production of pollutants by the base fire, if any. As we have said, the base fire is generated by burning firewood, which has lower calorific value than the typical hydrocarbon fuels. This ensures lower temperatures when oxides of nitrogen cannot be formed. The design of the vessel ensures plenty of oxygen and the amount of firewood burned is to the minimum extent so that carbon monoxide is minimal, as well as the unburned hydrocarbons. Carbon dioxide, a greenhouse gas is definitely formed, and therefore, it is suggested that the *agnihotra* ought to be performed during and after sunrise, and well before sunset in an area with sufficient green cover. Such local surroundings ensure that the carbon dioxide is well utilized by the green cover in the vicinity to give rise to oxygen and greenery. In the presence of sunlight the vegetation converts the carbon dioxide into oxygen, called photosynthesis. In the modern times, our life style gives rise to formation of carbon dioxide in very large proportions. In the olden days, carbon dioxide was not an undesirable combustion product. Though its control is required now, by any means *agnihotra* should not be criticized for the same. We should concentrate on other much larger sources of carbon dioxide because *agnihotra* has many advantages in the context of air pollution. We are not aware of any other method to purify

the air once that has been polluted by us, particularly the indoor air. This requirement is of enormous proportion for the indoor air because that is what we breathe in most of the time. This is becoming increasingly important because we are increasingly spending more time indoor, and our life style is doing more and more harm to the environment. In the given circumstances, *agnihotra* has become much more desirable. The air fresheners that are commercially available cannot purify the indoor air. Their purpose can be very limited to reduce the undesirable foul odor, and even for that purpose their side effects have to be fully understood.

Ancient *Rsis* had truly understood that *Agni* is a *devata* of insentient type because of its ability to return the substances to us in a form that magnifies the positive effects thereof by many hundred times. According to Yaska, a *devata* or a *deva* is one who gives us useful things, light or knowledge. In that sense *agnihotra* is a ritual to perform *devapuja*, and hence it is called *devayajna* too.

Summary: *Agnihotra* consists of a base fire wherein some desirable herbal substances are added. Since the calorific value of firewood is much less, the base fire causes vaporization of ghee and sublimation of the herbal substances with minimum combustion process. It is a well-known fact that the substances when taken in their vapor form through the nostrils have much greater efficiency – many hundred times more. And, the same quantity of substance can benefit a much larger population. It is a common experience that if an individual eats a green chilly then that person alone would be sneezing under its influence. But if the same chilly is put in the fire then the resultant air can cause many hundred people to sneeze. *Agnihotra* magnifies the advantages of the desirable herbal substances. Further to this, the thermal and associated aerodynamic effects of the base fire cause the vaporized substances to traverse and diffuse into every part of the enclosed surroundings where *agnihotra* may be conducted.

The overall temperatures in the combustion of firewood are lower to the extent that production of the oxides of nitrogen can be safely ruled out. Supply of more than adequate oxygen cannot give rise to production of unburned hydrocarbon or carbon monoxide in any significant measure. Minimum quantity of firewood is burned in the *agnihotra*. Burning of firewood is not the purpose of the *agnihotra*. The same is burned in minimum quantity so that the base fire remains available to vaporize the incoming oblations. Carbon dioxide, a greenhouse gas does get formed. With this in mind, the ancient Vedic seers always performed *agnihotra* in green surroundings and in the presence of sunlight so that the greenery utilizes the carbon dioxide so generated. In the modern times, when *agnihotra* is performed in cramped households care should be taken to keep some plants in the vicinity.

The process of *agnihotra* was in vogue in classical times. It is worth admiring the ancient scholars'

1) Understanding of the related chemistry and aerodynamic processes,
2) Desire to undo the harm that human beings do to the environment even with simplest and wisest life style that they had,

3) Desire to improve the environment not just for the personal good but also for the good of the entire society and other species, i.e. to be guided by a spirit of universal good,
4) Bold initiative to do a seemingly bizarre act of putting the useful substances into fire, which demonstrates their deep understanding of the properties of the matter and associated laws of conservation of mass, that of phase transformation at lower temperatures versus burning at higher temperatures, and
5) Identification of the properties of the purified butter (*ghrtam*) and other herbal substances and their utilization in the process of *agnihotra*.

Their contribution lies in identifying fire as the agent to multiply the benefits of the herbal substances through *agnihotra* in a ritual that otherwise may look to a layperson as a senseless act of throwing away the useful substances. Furthermore, they packaged the ritual in such a manner that it became a wonderful art of our overall development in all our domains, viz. physical, *pranic,* mental, intellectual and spiritual.

It can be safely stated that if this practice can become a common practice in the present times then this can lead to a marked decrease in several problems that the humanity is facing today. The gain can be tremendous in the quality of air, water and food that we consume, also in our mind set and behavioral pattern. People can come to possess a better physical and mental health, and a much more compassionate character that would have all-round effects on decrease in several ills that are present today. Let us hope and attempt to popularize it. With genuine well-coordinated effort *agnihotra* can become as popular as the practices of Yoga such as meditation have become among the educated and caring men and women throughout the world.